Abstract

This thesis deals with optical synthesis of unmodulated and modulated microwave signals. Generation of microwave signals based on optical heterodyning is discussed in detail.

The effect of phase noise of laser on heterodyned output has been studied for different phase noise profiles. Towards this, we propose a generic algorithm to numerically model the linewidth broadening of a laser due to phase noise. Generation of microwave signals is demonstrated practically by conducting an optical heterodyning experiment. Signals ranging in frequency from 12.5 MHz to 27 GHz have been generated.

Limitations of optical heterodyning based approach in terms of phase noise performance and frequency stability are discussed and practically demonstrated. A hardware-efficient Optical Phase Locked Loop (OPLL) is proposed to overcome these issues. Phase noise tracking performance of the proposed OPLL has been experimentally demonstrated. Phase noise values as low as -105 dBc/Hz at 10 KHz offset have been achieved.

Optical modulators, owing to their extremely low electro-optic response time, can support high frequency modulating signals. This makes them highly attractive in comparison to their microwave counterparts. In this thesis, we propose techniques to generate microwave signals modulated at very high bit rates by down-converting the corresponding modulated optical signals to microwave domain. Down-conversion required for this process is achieved by optical heterodyning. The proposed concept has been theoretically analyzed, simulated and experimentally validated. Amplitude Modulated and ASK modulated microwave signals have been generated as Proof-of-Concept.

Limitations posed by OPLL in generation of angle modulated microwave signals by optical heterodyning have been brought out. Schemes overcoming these limitations have been proposed towards generation of BPSK and QPSK modulated microwave signals.

Integrated Optics (IO) technology has been studied as a means of implementation of the proposed concepts. IO components like Sinusoidal bends, Y-branch splitters and Electro-Optic-Modulators (EOMs) have been designed towards optical synthesis of modulated microwave signals. Propagation of modulated optical signal through these IO components has also been studied.

An all-optic scheme based on Optical Beam Forming is proposed for transmission of QPSK modulated signal. Limitation of phase-shifting based approach, in terms of beam-squint, has been brought out. True-Time-Delay based approach has been proposed for applications demanding wide instantaneous bandwidth to avoid beam-squint.

Algorithms / numerical methods required for analyses and simulations associated with the above-mentioned tasks have been evolved.

This study is envisaged to provide useful insight into the realization of high-speed, compact, light-weight data transmitting systems based on Integrated Optics for future onboard spacecraft applications. This work, we believe, is a step towards realization of an Integrated Optic System-on-Chip solution for specific microwave data transmission applications.